

## **Chapter 4**

### **Continuous Monitoring of Carbon Monoxide**



**Chapter 4**  
**Continuous Monitoring of Carbon Monoxide**  
**Table of Contents**

	<b>Page</b>
<b>1.0 Introduction.....</b>	<b>1</b>
<b>2.0 Probe Siting Criteria.....</b>	<b>1</b>
2.1 Horizontal and Vertical Probe Placement.....	1
2.2 Spacing from Obstructions.....	1
2.3 Spacing from Roads.....	1
2.4 Spacing from Trees.....	1
<b>3.0 Monitoring Methodology.....</b>	<b>2</b>
3.1 Non-Dispersive Infrared Photometry (NDIR).....	2
<b>4.0 Calibration Methodology.....</b>	<b>2</b>
4.1 Safety Precautions.....	3
4.2 Multiple Cylinder Calibration.....	3
4.2.1 Determination of Concentration.....	3
4.2.2 Requirements for Calibration.....	3
4.3 Dilution System-Gas Blenders.....	4
4.3.1 Determination of Concentration.....	4
4.3.2 System Requirements.....	4
<b>5.0 Calibration Procedures.....</b>	<b>4</b>
5.1 Record Keeping.....	4
5.2 Calibration Process.....	5
5.3 Calibration Frequency.....	7
<b>6.0 Quality Assurance Audits.....</b>	<b>7</b>
6.1 Data Validation and Precision Audits.....	7
6.2 Accuracy Audits.....	11
6.2.1 Accuracy Audit Ranges.....	11
<b>7.0 Data Reduction and Reporting.....</b>	<b>12</b>
<b>8.0 Routine Station Operation.....</b>	<b>12</b>
8.1 Shelter Temperature.....	12
8.2 Shelter Sample Intake System.....	12
8.3 Recording Device.....	13
8.4 Analyzer Visual Checks.....	13
8.5 Level 2 Checks.....	13
<b>9.0 Preventive Maintenance.....</b>	<b>14</b>

## **TABLES**

<b>1.</b>	Minimum Separation Distance Between Roadways and Neighborhood Scale CO Stations.....	14
<b>2.</b>	Summary of National Ambient Air Quality Standards.....	15

## **APPENDICES**

<b>A.</b>	Conversion Factors and Formulas.....	16
<b>B.</b>	Calibration Form for Carbon Monoxide.....	18

## **1.0 Introduction**

Carbon monoxide (CO) is a colorless, odorless, tasteless gas produced by the incomplete combustion of hydrocarbons. Automobile emissions are the largest source of CO. CO is also present in large quantities in the emissions from industrial processes, such as coke plants and power stations.

It is the intent of this chapter to outline the monitoring, calibration, quality assurance, and data reporting requirements to be followed by all agencies (state, local, and independent) that conduct ambient CO monitoring within the State of Indiana.

## **2.0 Probe Siting Criteria**

Additional information can be found in Chapter 1 and in 40 CFR Part 58 Appendices, D and E.

### **2.1 Horizontal and Vertical Probe Placement**

1. The inlet probe (for microscale sites) must be 3 meters above ground level  $\pm 0.5$  meters.
2. The inlet probe (for neighborhood and middle scale sites) must be 3-15 meters above ground level.
3. The inlet probe must be located more than 1 meter in the vertical and horizontal direction from any supporting structure.

### **2.2 Spacing from Obstructions**

1. Air flow must be unrestricted in an arc of at least  $270^\circ$  around the probe, and the predominant wind direction for the season of greatest pollutant concentration must be included in that arc.
2. There must be  $180^\circ$  clearance for any probe located on the side of a building.

### **2.3 Spacing from Roads**

1. Microscale inlet probes must be between 2-10 meters from the nearest traffic lane.
2. Microscale inlet probes must be at least 10 meters from an intersection and preferably at mid-block.
3. See Table 1 for minimum separation distances between CO stations and roadways for neighborhood scale inlet probes.

### **2.4 Spacing from Trees**

1. Microscale stations should have no trees or shrubs between the inlet probe and the road.

2. There must be no trees located between the major sources of CO and the sampler for middle and neighborhood stations.
3. For middle and neighborhood scales, the sample inlet must be at least 10 meters from the drip line of a tree that is between the sampler and the road and extends at least 5 meters above ground level.

### **3.0 Monitoring Methodology**

#### **3.1 Non-Dispersive Infrared Photometry (NDIR)**

CO absorbs infrared radiation (IR) at known frequencies. This fact allows for accurate measurement of CO. When IR passes through a sample cell, CO absorbs a portion of the IR. This measurement method compares the amount of IR passing through the sample cell with the amount of IR passing through a CO free reference cell. Next, the method converts this difference in IR absorption passing through the two cells to an output signal.

CO analyzers must be reference or equivalent as described in the Code of Federal Regulations (CFR) 40 Part 50.1. A list of equivalent analyzers is available by writing to:

U.S. EPA Environmental Monitoring Systems Laboratory  
Department E, MD-77  
Research Triangle Park, NC 27711

Or on the world wide web on the Technology Transfer Network (TTN) Air Monitoring Technology Information Center (AMTIC) Web Page at <http://www.epa.gov/ttnamt1/> under "Monitoring Methods".

Requirements for monitoring CO (include but are not limited to):

1. Incoming sample air must not be pressurized.
2. Air flow to the sampler from the inlet sample probe must be unrestricted.

#### **4.0 Calibration Methodology**

Dynamic calibration involves introducing gas samples of known concentration to an instrument in order to adjust the instrument to a predetermined measurement range and to derive a calibration relationship.

There are currently two methods used to calibrate CO analyzers, multiple cylinder calibration and dilution system-gas blender calibration. Always refer to the manufacturer's instruction manual for analyzer-specific directions that may be unique to the calibration of a particular instrument.

## **4.1 Safety Precautions**

CAUTION: Carbon monoxide gas is lethal in high concentrations, and can cause adverse health effects with prolonged exposures to lower concentrations (faintness, dizziness, nausea, vomiting, and even brain damage). Because it is colorless, odorless, and tasteless, extreme care should be taken to leak test all fittings and shut-off valves whenever using, transporting, or storing CO cylinders. Calibration systems exhaust air into the room, so it is necessary to vent the exhaust port to the outside whenever possible or use with adequate ventilation.

## **4.2 Multiple Cylinder Calibration**

The multiple cylinder method of calibration involves using two or more pressurized gas cylinders containing two different known concentrations of CO. There are three types of standard gases generally available:

1. National Institutes of Standards and Technology-Standard Reference Material (NIST-SRM)
2. Certified Reference Material (CRM)
3. Non-CRM vendor certified

The use of non-CRM vendor supplied gas is acceptable; however, all gases used must be certified against the Office of Air Quality's (OAQ) primary standards.

### **4.2.1 Determination of Concentration**

The concentration supplied to the CO analyzer in a multiple cylinder calibration will be that value given (to each specific cylinder used) at certification.

### **4.2.2 Requirements for Calibration (include but are not limited to):**

1. Certified cylinder(s). Four cylinders using the direct cylinder method. If using a gas dilution system, only one cylinder is needed (see Section 4.3).
2. A moisture-free calibration system
3. Leak free gas connections
4. A zero air source free of CO and moisture
5. A manifold system for delivery of gas
6. A flow control device (e.g. rotameter). Gas dilution system flow meters must be certified (see Section 4.3).

### 4.3 Dilution System-Gas Blenders

This system consists of one cylinder of CO (of known concentration), a source of (zero) air free of CO and moisture, and a mixing/blending system. Dilution and gas flow may be measured with either the system's built-in certified flow meters, external certified flow devices (e.g. Bios, Gilibrator), or manually using an NIST traceable bubble meter kit.

#### 4.3.1 Determination of Concentration

Use the following formula to determine the concentration of the CO introduced into the analyzer:

$$[\text{CO}]_{\text{out}} = \frac{[\text{CO}]_{\text{std}} \times F_{\text{CO}}}{F_{\text{D}} + F_{\text{CO}}}$$

Where:

- $[\text{CO}]_{\text{out}}$  = diluted CO concentration at the output manifold, in ppm
- $[\text{CO}]_{\text{std}}$  = concentration of the undiluted CO standard, in ppm
- $F_{\text{CO}}$  = flow rate of the CO standard corrected to 25°C and 760 mmHg, in L/min
- $F_{\text{D}}$  = flow rate of the dilution air corrected to 25°C and 760 mmHg, in L/min

Note: Flow must be corrected to Standard Reference Conditions (SRC). See Appendix A for formulas.

#### 4.3.2 System Requirements (include but are not limited to):

1. The dilution (zero) air must be dry and free of CO (<0.1 ppm).
2. A certified flow measuring system

### 5.0 Calibration Procedure

The calibration procedure outlined below is general. Always refer to the manufacturer's instruction manual for analyzer-specific alterations or explanations.

#### 5.1 Record Keeping

Each calibration should be accompanied by a completed calibration worksheet. Appendix B represents an example. If a generic form is desired, include the following information:

1. Official site name (include AQS Number)
2. Instrumentation identification (include manufacturer's name, model and serial number)
3. Identification of person performing the calibration



4. Date of calibration
5. Calibrator identification (include manufacturer's name, model and serial number)
6. Cylinder(s) identification and concentration (include manufacturer's name and serial number)
7. Date of cylinder(s) certification
8. The site temperature in degrees Celsius ( $^{\circ}\text{C}$ ) and ambient pressure in millimeters of mercury (mmHg)
9. The analyzer's sample air flow, vacuum pressure, initial and final zero/span potentiometer settings
10. Span cylinder identification (include manufacturer's name and serial number)
11. Date of last calibration
12. The initial and final time (of the calibration)
13. Calibrator setting/bubble tube flow
14. Calibration result; i.e., percent difference of all points

Label the primary and secondary recording units and document the station logbook with the information listed below to avoid any confusion when reducing the raw data:

1. Site identification
2. Initials of person performing the calibration
3. Parameter (CO)
4. Start/stop time
5. Results

## **5.2 Calibration Process**

1. Attach the analyzer's sample line to the vented output of the calibrator. Adjust the zero air flow from the calibrator to the analyzer. The zero air flow must exceed the analyzer's total demand by 25% (for air flow) to ensure the analyzer pump does not draw ambient air into the system through the vent.

2. Allow enough time for the monitor to attain a stable zero response. It is recommended that the recorder's zero control offset the chart response to +5%. This allows observation of the negative zero drift. Record the responses on the calibration worksheet.
3. Determine the concentration corresponding to 80% of the analyzer's range (i.e., for an analyzer operating in the 0-50 ppm range, 80% would be 40 ppm).
4. If using a gas blender system, determine the calibrator settings necessary to achieve the correct output by using the equations listed in Section 4.3. If using the multiple cylinder method, attach the cylinder with the correct concentration.
5. Allow the analyzer to sample until the response is stable and then adjust the span control until the required response is obtained.
6. Once the span control has been adjusted, recheck the zero and span by repeating steps 2-5. After setting the zero and 80% points, introduce at least one additional point between the 0-80% range, making no further adjustments on the zero/span control. Record the standard concentrations (those introduced by the calibration system) and the analyzer response (observed concentration) on the calibration worksheet.
7. Determine the percent difference for each set of points using the following formula:

$$\% \text{ Difference} = \frac{\text{Observed Conc} - \text{Std Conc}}{\text{Std Conc}} \times 100$$

Use the following formula to determine the observed concentration:

$$\text{Observed Conc} = (\text{Primary Recorder Response} - \text{Baseline}) \times \text{Calibration Slope}$$

And to determine the primary recorder response, use this formula:

$$\text{Primary Recorder Response (\% scale)} = \frac{[\text{CO}]_{\text{out}}}{\text{URL}} \times 100 + Z_{\text{CO}}$$

Where:

$$\begin{aligned} [\text{CO}]_{\text{out}} &= \text{diluted CO concentration at the output manifold, in ppm} \\ \text{URL} &= \text{nominal upper range limit of the analyzer's operating range} \\ Z_{\text{CO}} &= \text{analyzer response to zero air, \% scale} \end{aligned}$$

8. Repeat any points falling outside  $\pm 2\%$  (of the line of best fit) to eliminate calibration errors. If the repeated points are still outside the 2% limits, the calibration is considered invalid. If a successful calibration cannot be completed in two attempts, the instrument must be

considered suspect, and maintenance may be required. No data will be accepted without a valid calibration.

### **5.3 Calibration Frequency**

To ensure accurate CO measurements, calibrate the analyzer at the time of installation and recalibrate at the following times:

1. No later than six months after the most recent calibration
2. An interruption of more than 24 hours of the analyzer's operation
3. Any major repairs
4. Physical relocation of the unit
5. Any performance audit failure or excessive zero/span drift

A Level 2 zero/span check (see Section 8.5) may be used to determine if a calibration is necessary should conditions listed above occur. However, you may not substitute a Level 2 check for a scheduled 6 month calibration.

## **6.0 Quality Assurance Audits**

Quality assurance audits ensure the validity of the CO data submitted to the national AQS data bank. Results of these audits are also used to estimate the Precision and Accuracy (P&A) of the monitoring network's data. IDEM/OAQ/QAS submits the statewide P&A to the United States EPA every quarter. See Chapter 13, "Quality Assessment and Statistical Analysis of Air Monitoring Data," of this manual for detailed information on P&A.

### **6.1 Data Validation and Precision Audits**

Routine audits are performed biweekly to assess the validity and precision of the CO data. An audit consists of challenging the analyzer with two upscale CO concentrations. The procedure is similar to a calibration, and can be done using either the direct cylinder method, or gas dilution method. The audit device must meet the same criteria as that of the system used for the calibration. It must also be certified by the IDEM-OAQ-QAS (see Section 4.0 of this chapter, and Chapter 6 of this manual, "Certification Methods for Transfer Standards").

During a biweekly audit, the first audit point is a CO concentration 70-90% of the upper range limit (URL). This would be 35 ppm to 45 ppm for a monitor with a range of 50 ppm. This concentration is the validation point, or Level 3 check, and is used to validate data back to the most recent audit or calibration. See Chapter 11, "Valid Data Requirements," in this manual for the details of data validation.

The second audit point consists of a CO concentration in the required range of 8-10 ppm, regardless of the monitor's URL. This second audit point is used to assess the precision of the data based on quarterly calculations.

The following CO concentrations must be run for a validation/precision audit:

Monitor Range	Analyzer Range
0 - 50 ppm	35 – 45 ppm Validation point
	8 - 10 ppm Precision point
0 - 100 ppm	80 – 90 ppm Validation point
	8 - 10 ppm Precision point

Although the same person can calibrate and conduct audits on the analyzer using the same calibration system, it is suggested that a different *person* conduct the audits than the one who performed the calibration.

The field audit procedure is as follows:

**NOTE: MAKE NO ADJUSTMENTS TO THE ANALYZER BEFORE THE AUDIT**

1. Record the station name.
2. Identify the person performing the audit (initials) and record the audit date.
3. Record the analyzer's manufacturer name, model number, and serial number.
4. Record the analyzer's settings: flows, vacuum, initial and final zero and span potentiometer settings into the site logbook. Analyzer controls will vary with each manufacturer's brand and model. Also record the results of any diagnostics performed on the analyzer. Analyzers controlled by microprocessors have no potentiometers but will have readings that correspond to the zero and span potentiometer settings. Record these readings. Because calibration adjustments will differ between analyzer models, consult the manufacturer's manual before performing the calibration.

NOTE: It is good practice to inspect the analyzer before the start of the field audit. Examples -- Check that the analyzer is in the normal sampling mode. Make sure the sample line is connected to the sample manifold or outside sample line. Also check that the analyzer is connected to the data recording device(s) or any other condition that could affect the data or the field audit results.

5. Record the analyzer's last calibration date. Analyzers must have a multi-point calibration (see Section 5.2 of this Chapter) at least once every six months.

6. Record the audit device manufacturer name, model number, and serial number.
7. For each CO audit gas cylinder, record its manufacturer, serial number, certified concentration, certification date, and cylinder pressure.

**NOTE: DO NOT USE CYLINDERS WITH PRESSURES < 200 PSIG. GASES MAY BECOME UNSTABLE AT LOW PRESSURES AND CAUSE AUDIT ERRORS.** Be sure that the audit system and/or cylinder(s) have a current certification (within the last 6 months for dilution systems and within the last 24 months for direct gas cylinders) before proceeding.

8. Record the primary and secondary recording device (usually a computer data logger and chart recorder respectively). A digital voltmeter (DVM) may be used if the site's primary and secondary recorders are suspect or malfunctioning.
9. Confirm that the analyzer is connected to a recording device (e.g., a data acquisition system (DAS), a strip chart recorder, and/or a digital voltmeter).

**NOTE: AMBIENT NETWORK SITES THAT USE A DATA ACQUISITION SYSTEM (DAS) MAY RECORD THE AUDIT CONCENTRATIONS AS AN EXCEEDANCE; THEREFORE, IT IS IMPORTANT TO LOG ON TO THE DAS AND DISABLE THE APPROPRIATE CHANNELS BEFORE STARTING SO THAT THOSE VALUES CAN BE FLAGGED.**

10. Adjust the flow on the audit device so that its total output flow exceeds the total flow demand of the analyzer by at least 25%.
11. Connect the analyzer's "sample in" port to the "sample out" port of the audit device using a vented nonreactive (e.g., Teflon) sample line or manifold.

**NOTE:** Log on and annotate all data recording devices (e.g., data acquisition system or strip chart recorder) with the audit starting date and time.

**WARNING: THE SAMPLE GAS MUST BE DELIVERED TO THE ANALYZER AT ATMOSPHERIC PRESSURE. A MANIFOLD OR TEE VENT MUST BE USED FROM THE AUDIT DEVICE SO THAT EXCESS SAMPLE FLOW CAN BLEED OFF. A NON-VENTED SAMPLE GAS MAY PRESSURIZE AND DAMAGE THE ANALYZER.**

12. Allow the analyzer to sample zero air until the CO response stabilizes. Record the analyzer response to zero air.
13. If using a cylinder dilution system, attach a stainless steel or brass regulator to the CO cylinder. Attach the gas line to the audit system.

14. Introduce the validation concentration into the analyzer via direct cylinder method or gas dilution method. The validation point can range between 70% and 90% of the URL of the CO analyzer (e.g. 35 to 45 ppm for the typical URL of 50 ppm). If using a gas dilution system with certified flow meters, be sure that the validation point does not exceed the highest point of the calibration used to certify the audit equipment.
15. If using the cylinder dilution method, calculate the exact CO concentration,  $[CO]_{out}$ , by following the calculation in Section 4.3.1. Record the concentration, audit setting, gas flow, and total flow.
16. After the analyzer response has stabilized, record the responses.
17. To convert the analyzer response from the primary recording device to a concentration (ppm), subtract the initial background response (step 13) from the current analyzer response. This is the observed, or measured, concentration.
18. Calculate and record the percent difference between the standard concentration (std. conc.) and the observed concentration (obsv. conc.). See Formulas in Appendix A to calculate the percent difference.
19. The results of the validation audit will determine one of the following three outcomes:
  - a. If the percent difference for the CO validation audit is less than  $\pm 7.5\%$ , the collected data is valid and the audit may proceed.

**NOTE:** Because P&A data is reported to the nearest tenth of a percent, QAS suggests that the percent difference be rounded to the nearest tenth of a percent (X.X).
  - b. If the percent difference for the CO validation audit is between  $\pm 7.5\%$  and  $\pm 15.0\%$ , then the network operator must be informed that the analyzer is out of calibration. The data collected since the last audit or calibration is valid, but a recalibration must be done as soon as possible. The CO precision audit must proceed.
  - c. If the percent difference for the CO validation audit is greater than  $\pm 15.0\%$ , then the audit is complete. However, it may be helpful to continue the audit to diagnose problems. The data collected since the last audit or calibration is invalid. The analyzer must be recalibrated before data will be valid again.
20. For the CO precision audit, introduce a concentration of 8-10 ppm, (via direct cylinder method or gas dilution method). This is the required range for the precision audit concentration. The steps involved with the precision audit are the same as for the data validation point. Results of precision point audits are used in quarterly calculations of a monitoring network's precision.
21. Introduce zero air into the analyzer again to ensure consistent zero air readings.

After any type of audit is complete, perform the following:

1. Reconnect the analyzer's sample line to the outside sample line or manifold.
2. Ensure that the analyzer is in the normal sampling mode and has its normal flow.
3. Ensure that the data recording devices are connected to the analyzer and are registering an appropriate response.
4. Log off and annotate all data recording devices with the type of activity performed. In this case, the activity is an audit. Any unusual results or circumstances should be noted here.
5. For a strip chart recorder, be sure to indicate the following information on the chart: site name, audit starting and ending time, chart speed, date, parameter, and the auditor's initials.

Record all applicable information in the site logbook. Include at least the audit date, the initials of the auditor, the type of audit (validation/precision and/or accuracy), and the percent difference results of the validation and precision audits.

## **6.2 Accuracy Audits**

Accuracy audits must be performed on at least 25% of the network analyzers each calendar quarter as per 40 CFR Part 58. At the end of the year, all analyzers must have had an accuracy audit. To ensure accuracy audits are not missed, it is strongly recommended that an accuracy audit be performed on each analyzer once per quarter.

Networks having four or fewer analyzers must conduct audits so that all analyzers have had an accuracy audit by the end of the year. Accuracy would then be calculated in the 2nd and 4th quarters of the year. Because this is a statistical assessment of the accuracy of the data, it is suggested that accuracy audits be conducted more often than once per quarter (e.g., monthly). This ensures a larger and more representative database for the accuracy calculations.

40 CFR Part 58 requires that a different audit system and gas standard from that of the calibrator be used to perform the accuracy audit. The auditor should also be different from that of the person who performed the calibration. The analyzer must be collecting valid data in order to conduct an accuracy audit.

### **6.2.1 Accuracy Audit Ranges**

To perform accuracy audits, follow the same auditing procedures and calculations used in Section 6.1.

The following CO concentrations must be run for an accuracy audit:

Monitor Range	Concentration
0-50 ppm	3 - 8 ppm (Level 1)
	15 - 20 ppm (Level 2)
0 - 100 ppm	35 - 45 ppm (Level 3)
	80 - 90 ppm (Level 4)

Use the Level 4 accuracy point only on those analyzers calibrated to a 100 ppm range.

## 7.0 Data Reduction and Reporting

The U.S. EPA bases National Ambient Air Quality Standards (NAAQS) for CO on measured hourly average concentrations. Table 2 of this chapter, lists the NAAQS for CO. The data submitted to the State for entry into AQS must be reduced to 24 hourly average concentrations daily. This reduction must be done manually in networks not equipped with electronic averaging instrumentation. See Chapter 12 of this manual for the methodology and quality assurance requirements for data reduction. Data should be submitted to IDEM by the 15th of the following month to allow sufficient time for review before EPA deadlines (within 90 days after the end of each reporting period).

## 8.0 Routine Station Operation

Scheduled checks are essential to the quality assurance program for verifying the validity of the monitoring system. At least once each week, the network operator should visit each site to physically determine the operating conditions.

### 8.1 Shelter Temperature

Mean shelter temperature should be between 20°C and 30°C. A certified thermograph or other temperature recording device must be installed at the site to continuously monitor the daily temperature fluctuations (40 CFR Part 53.31(a)). Data may be invalidated whenever the shelter temperature falls out of the 15°C to 33°C range.

### 8.2 Shelter Sample Intake System

The following components should be inspected weekly for breakage, leaks, and build up of particulate matter or moisture:

1. Intake port
2. Particulate and moisture traps (change or empty as needed)
3. Sampling manifold and blower
4. Analyzer sampling line



### 8.3 Recording Device

Whether using a computer printout, a strip chart, or both, check the following weekly:

1. Ink trace or printout for legibility
2. Ink or ribbon reservoir
3. Paper supply
4. Time synchronization
5. Agreement among recording devices

### 8.4 Analyzer Visual Checks

The field operator should check the operating parameters of the analyzer weekly. These will vary from instrument to instrument but in general will include:

1. Correct settings on flow meters and regulators
2. Verification of sample mode
3. Zero and span potentiometers set and locked
4. Abnormal electronic noise or temperature
5. CO span cylinder pressure

### 8.5 Level 2 Checks

Configure continuous analyzers to perform Level 2 checks daily. A zero concentration and a concentration of 70-90% of the URL should be introduced into the analyzer. Most instruments have an internal or automatic capacity to cycle through a zero/span each day. If an instrument does not have this capacity, this zero/span should be done manually at least once per week. If an analyzer drifts excessively, more frequent zeroes and spans will be required. Although not used specifically for data validation/invalidation, it does help to track a monitor's drift pattern, and may show at what particular point a monitor began to display any kind of trend. If a biweekly audit exceeds the allowed percent difference and records of zero/span checks can be supplied to identify when excessive drift began, it may not be necessary to invalidate an entire operational period. Decisions on data validation would then rest with the QAS Chief. The drift limit for the zero is 2.0% of *chart*. The drift limit for span is 5.0% of *scale*.

## 9.0 Preventive Maintenance

Analyzers must have routine preventive maintenance performed to ensure proper operation. Most manufacturers supply a preventive maintenance checklist with the instruction manual. An analyzer-specific schedule, similar to that shown below, should be located at each site. All maintenance should be recorded in the station logbook.

**Sample Preventive Maintenance Schedule**

Item	Action Required	Date Due	Date Performed	Next Date Due
Particulate Filter	Change	06/06/05	06/06/05	06/22/05
Pump Diaphragm	Change	06/01/05	06/06/05	12/01/05
Fan Filter	Examine	06/01/05	06/06/05	07/01/05
Span Cylinder	Check	Weekly		
Fitting	Check	Weekly		
Etc.				

**Table 1**  
**Minimum Separation Distance Between**  
**Roadways and Neighborhood Scale CO Stations**

Average Vehicles (per day)	Minimum separation (meters) <sup>1</sup>
≤10,000	10
15,000	25
20,000	45
30,000	80
40,000	115
50,000	135
60,000 or over	Greater than 150

(1) Distances should be interpolated based on traffic flow.

**Table 2**  
**Summary of the National Ambient**  
**Air Quality Standards**

<b>Pollutant</b>	<b>Time of Average</b>	<b>Primary Standard</b>	<b>Secondary Standard</b>
Ozone (O <sub>3</sub> )	3-year Average of the Annual 4 <sup>th</sup> Highest Daily Maximum 8-Hour Ozone Concentrations Not Exceeding 0.08 ppm <sup>1</sup>	0.085 ppm	Same As Primary
Sulfur Dioxide (SO <sub>2</sub> )	Annual Arithmetic Mean 24-Hour Average 3-Hour Average	0.03 ppm 0.14 ppm None	None None 0.5 ppm
Carbon Monoxide (CO)	8-Hour Average 1-Hour Average	9 ppm 35 ppm	Same As Primary Same As Primary
Nitrogen Dioxide (NO <sub>2</sub> )	Annual Arithmetic Mean	0.053 ppm	Same As Primary
Lead (Pb)	Quarterly Arithmetic Mean	1.5 µg/m <sup>3</sup>	Same As Primary
Particulate Matter (PM <sub>10</sub> )	Annual Arithmetic Mean 24-Hour Average	50 µg/m <sup>3</sup> 150 µg/m <sup>3</sup>	Same As Primary Same As Primary
Particulate Matter (PM <sub>2.5</sub> )	Annual Arithmetic Mean 24-Hour Average	15 µg/m <sup>3</sup> 65 µg/m <sup>3</sup>	Same As Primary Same As Primary

(1) The previous standard of 0.12 ppm for 1-hour will still be in place until data from a given area is reviewed and found to meet the 1-hour standard.

## Appendix A Conversion Factors and Formulas

mmHg = inches of Hg x 25.4 mm/inch

Degrees Celsius (°C) = (°F - 32) x 5/9

Kelvin (K) = (°C + 273K)

### Vapor Pressure

Temperature (°C)	mmHg (H <sub>2</sub> O)
20.....	17.5
21.....	18.6
22.....	19.8
23.....	21.1
24.....	22.4
25.....	23.8
26.....	25.2
27.....	26.7
28.....	28.3
29.....	30.0
30.....	31.8

Standard Reference Conditions (SRC):

Standard Barometric Pressure (P<sub>STD</sub>) = 760 mmHg

Standard Temperature (T<sub>STD</sub>) = 298K or (25°C + 273K)

### Formulas

1. Correction of flow rate to SRC:

$$\text{Correction Factor} = \frac{(P_{\text{AMB}} - P_{\text{VAP}}) \times T_{\text{STD}}}{T_{\text{AMB}} \times P_{\text{STD}}}$$

Where:

P<sub>AMB</sub> = Ambient Barometric Pressure in mmHg  
P<sub>VAP</sub> = Vapor Pressure of H<sub>2</sub>O  
T<sub>AMB</sub> = Ambient Air Temperature in K

2. Flow Rate (measured with a bubble meter):

$$\text{Flow Rate @ SRC} = \frac{\text{Volume Measured (cc or liters)}}{\text{Time (sec)/60 sec/min}} \times \text{SRC Correction Factor}$$

3. Calculation of a ppm concentration from a gas blended cylinder:

$$\text{ppm} = \frac{\text{Cylinder Concentration (ppm)} \times \text{Cylinder Flow Rate}}{\text{Dilution low Rate} + \text{Cylinder Flow Rate}}$$

4. Calculation of True Flow Rate from a Mass Flow Meter:

$$\text{True Flow Rate} = (\text{Meter Reading} \times \text{Calibration Slope}) \pm \text{Intercept (cc or liters)}$$

5. Calculation of Observed Concentration:

$$\text{ppm} = (\text{Monitor Response} - \text{Zero Response}) \times \text{Calibration Slope}$$

6. Calculation of Percent Difference:

$$\% \text{ Difference} = \frac{\text{Observed Concentration (ppm)} - \text{Standard Concentration (ppm)}}{\text{Standard Concentration (ppm)}} \times 100$$

#### **Accuracy Audit Concentrations (ppm)**

<u>Level</u>	<u>CO</u>
1	3 - 8
P*	8 - 10
2	15 - 20
3	35 - 45
4	80 - 90

\*Precision

## Appendix B Carbon Monoxide (CO) Calibration

SITE: \_\_\_\_\_ AQS #: \_\_\_\_\_ INITIALS: \_\_\_\_\_

DATE: \_\_\_\_/\_\_\_\_/\_\_\_\_ START TIME: \_\_\_\_\_ END TIME: \_\_\_\_\_

<b>ANALYZER INFORMATION</b> <b>Original Monitor</b> Brand/Serial #: _____ Range: _____ Flow Rate: _____  Orig. Zero Setting: _____ Adjusted Zero: _____ Orig. Span Setting: _____ Adjusted Span: _____ <b>IF MONITOR Changed</b> , New Monitor Brand SN: _____ Span: _____ Zero: _____	
<b>Validation Point</b>  DAS: _____ DVM: _____ %Chart: _____ STD: _____ Meas Conc: _____ % Dif: _____  Cyl Press: _____ Cyl Number: _____ Cyl Standard Conc.: _____  Zero DAS: _____ DVM: _____ %Chart: _____ Monitor: _____	

### CALIBRATION DATA

Primary Recording Device: \_\_\_\_\_ Units: \_\_\_\_\_ Secondary: \_\_\_\_\_ Units: \_\_\_\_\_

### CALIBRATION RESULTS

<b>Zero Response:</b> DVM: _____ %Chart: _____ Monitor: _____ DAS: _____					
Cylinder Pressure	Cylinder Number	Standard Cyl. Conc.	Response	Measured Conc. in PPM	PERCENT DIFFERENCE
			DVM		
			% DAS		
			DVM		
			% DAS		
			DVM		
			% DAS		
			DVM		
			% DAS		
<i>Span Response</i>		<i>Not Certified</i>	DVM		N/A
			% DAS		

### Diagnostics

Comments:	S/R Ratio: _____ (1.15-1.18) AGC: _____/_____ (approx. 36K) Int: _____/_____ (10K-30K) Pressure: _____ Temp: _____
-----------	--